Scaffold Informatics: A Bioinformatics Approach for Tissue Scaffold Modeling and Construction

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The extracellular matrix that tissue scaffolds attempt to emulate are of great complexity, for integrated within the scaffold are instructions that direct cell attachment, proliferation, differentiation, and the growth of new tissue. In order to fulfill its function, an ideal tissue scaffold should be designed to mimic the appropriate structure and characteristics of the desired tissue in terms of biocompatibility, architecture, environment, and chemical composition. In addition, the construction of the scaffold must be achieved at multiple organizational levels, spanning from the micro-scale for cell-printing, to the macro-scale for organ-printing. The scaffold must also have incorporated within it heterogeneous scaffold materials, a controlled spatial distribution of growth factors, and an embedded microarchitectural vascularization for cellular nutrition, movement, and chemotaxis. Consideration of these multiple biological, biomechanical and biochemical issues can be represented by a comprehensive "scaffold informatics" model. This poster will present the database and informational content of the scaffold informatics model, its multi-scale modeling process, and its role in computer-aided tissue engineering. An example will be given using the informatics model for the design and freeform fabrication of a tissue scaffold consisting of a hybrid polycaprolactone superstructure with degradable alginate elements. Also, the computational characterization of the scaffold for mechanical, morphological, and structural properties, and the application of degradable scaffold elements for computationally predicting localized diffusion of growth factors will be described. The biological implications of the developed technique and the scaffold informatics model could be significant – ranging from the controlled release of growth factors within a 3D scaffold, to the design and introduction of tissue angiogenesis, and also from the creation of a multiple tissue assembly, to the formation of a complex heterogeneous tissue scaffold for soft-hard tissue interface and applications. The challenges involved in the development of the scaffold informatics model and in the computational characterization of the superstructure and diffusive properties of the hybrid scaffold will also be discussed.